Claims

What is claimed is:

1. A photodiode comprising:

a) a semiconductor intrinsic light absorption layer having a thickness t_i;

b) at least one of a p-doped light absorption layer and an n-doped light absorption layer; wherein the p-doped light absorption layer has thickness t_p and the n-doped light absorption layer has a thickness t_n, and wherein $(t_p + t_n)/t_i$ is greater or equal to 0.17, wherein $t_i > 0$; or wherein at least one of the p-doped light absorption layer and the n-doped light absorption layer have a doping concentration of d_c between 1e16 and 5e18 cm^{-3} and wherein the concentration of any doping present in the intrinsic layer is 3e15 cm^{-3} or lower; and,

c) a cathode electrode and an anode electrode electrically couple with the n-doped light absorption layer or the p-doped light absorption layer, respectively.

2. A photodiode as defined in claim 1 wherein $(t_p + t_n)/t_i \geq 0.20$, and wherein both the p-doped light absorption layer and the n-doped light absorption layer have a doping concentration of d_c in between 1e16 and 5e18 cm^{-3}.

3. A photodiode as defined in claim 1 wherein $t_n = 0$

4. A photodiode as defined in claim 1, wherein $t_p = 0$

5. A photodiode as defined in claim 2 wherein $(t_p + t_n)/t_i \geq 0.45$.

6. A photodiode as defined in claim 1 wherein the dopant concentration d_c layers is in between 1e17 and 2e18 cm^{-3}, while the intrinsic layer has doping below 5e14 cm^{-3}.

7. A photodiode as defined in claim 2, wherein the semiconductor intrinsic layer and the at least the p-doped light absorption layer or the n-doped light absorption layer are sandwiched between the cathode and anode electrodes.

8. A photodiode as defined in claim 2, wherein the light absorption layers consist a p-doped light absorption layer, and the intrinsic light absorption layer, said layers being adjacent to one another.

9. A photodiode as defined in claim 2, wherein the light absorption layers consist an n-doped light absorption layer, and the intrinsic light absorption layer, said layers being adjacent to one another.

10. A photodiode as defined in claim 1, wherein the total thickness of the doped and intrinsic light absorption layers is greater than $v/(2f_{3\text{-dB}})$ by 20% or more, where v is the saturation drift velocity of either the electron or the hole, whichever is smaller, in the intrinsic light-absorbing layer, wherein $f_{3\text{-dB}}$ is the frequency at which the amplitude of responsivity of the photodetector is reduced to $1/\sqrt{2}$ of its DC low-frequency value.

11. A photodiode as defined in claim 6, wherein the total thickness of the doped and intrinsic light absorption layers is greater than $v/(2f_{3\text{-dB}})$ by 20% or more, where v is the saturation drift velocity of either the electron or the hole, whichever is smaller, in the intrinsic light-absorbing layer, wherein $f_{3\text{-dB}}$ is the frequency at which the amplitude of responsivity of the photodetector is reduced to $1/\sqrt{2}$ of its DC low-frequency value.

12. A photodiode as defined in claim 8, wherein the total thickness of the doped and intrinsic light absorption layers is greater than $v/(2f_{3\text{-dB}})$ by 20% or more, where v is the saturation drift velocity of either the electron or the hole, whichever is smaller, in the intrinsic light-absorbing layer, wherein $f_{3\text{-dB}}$ is the frequency at which the amplitude of responsivity of the photodetector is reduced to $1/\sqrt{2}$ of its DC low-frequency value.

13. A photodiode as defined in claim 1, wherein the presence of the p-doped or n-doped absorption layer increases by 20% or more the responsivity x bandwidth product over a p-i-n consisting of an anode a cathode and an intrinsic layer sandwiched therebetween under the same temperature and bias conditions.

14. A photodiode as defined in claim 1 including an avalanche multiplication layer, wherein the responsivity x avalanche-multiplication-gain x bandwidth product exceeds by 20% or more the responsivity x avalanche-multiplication-gain x bandwidth product of a same diode in the absence of said doped absorption layer under the same temperature and bias conditions.

15. A photodiode as defined in claim 14 having a separate absorption and multiplication layer.

16. A photodiode as defined in claim 1 with a 3-dB bandwidth frequency of 40GHz or higher, wherein the doped and intrinsic absorption layers are InGaAs lattice-matched to InP, and the total thickness of the doped and intrinsic light absorption layers is greater than 0.60 microns.

17. A photodiode as defined in claim 1 with a 3-dB bandwidth frequency of 40GHz or higher, wherein the doped and intrinsic absorption layers are InGaAs lattice-matched to InP, and the total thickness of the doped and intrinsic light absorption layers is greater than 0.65 microns.

18. A photodiode as defined in claim 1, having a 3-dB bandwidth frequency of 40GHz or higher, wherein the doped and intrinsic absorption layers are InGaAs lattice-matched to InP, and the total thickness of the doped and intrinsic light absorption layers is greater than 0.70 microns.